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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF: Simon POWELL

SERIAL NO.: NEW U.S. PCT APPLICATION

FILED: HEREWITH

INTERNATIONAL APPLICATION NO.: PCT/GB00/01508

INTERNATIONAL FILING DATE: 18 April 2000

FOR: ACTIVE MATERIAL LOW POWER ELECTRICAL SWITCHING MECHANISM
AND DRIVE CIRCUIT THEREFOR**REQUEST FOR PRIORITY UNDER 35 U.S.C. 119
AND THE INTERNATIONAL CONVENTION**Assistant Commissioner for Patents
Washington, D.C. 20231

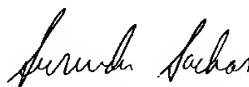
Sir:

In the matter of the above-identified application for patent, notice is hereby given that the applicant claims as priority:

<u>COUNTRY</u>	<u>APPLICATION NO.</u>	<u>DAY/MONTH/YEAR</u>
Great Britain	9908930.2	19 April 1999

A certified copy of the corresponding Convention application(s) was submitted to the International Bureau in PCT Application No. **PCT/GB00/01508**.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.

Marvin J. Spivak
Attorney of Record
Registration No. 24,913
Surinder Sachar
Registration No. 34,423**22850**

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**REQUEST FOR CONSIDERATION OF DOCUMENTS
CITED IN INTERNATIONAL SEARCH REPORT**

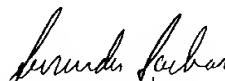
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

In the matter of the above-identified application for patent, notice is hereby given that applicant(s) request that the Examiner consider the documents cited in the International Search Report according to MPEP §609 and so indicate by a statement in the first Office Action that the information has been considered. When the Form PCT/DO/EO/903 indicates both the search report and copies of the documents are present in the national stage file, there is no requirement for the applicant(s) to submit them (1156 O.G. 91 November 23, 1993).

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.



Marvin J. Spivak
Attorney of Record
Registration No. 24,913
Surinder Sachar
Attorney of Record
Registration No. 34,423



22850

(703) 413-3000
Fax No. (703) 413-2220
(OSMMN 1/97)

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INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

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Dated

22nd May 2000

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The
Patent
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20APR99 1441054-5 D00186
P01/7700 0.00 - 9908930.2

Request for grant of a patent

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19 APR 1999

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

ABC / B

2. Patent application number

(The Patent Office will fill in this part)

9908930.2

3. Full name, address and postcode of the or of each applicant (underline all surnames)

PBT (IP) Limited

1 Astra Centre

Edinburgh Way

Harlow

Essex CM20 2BN

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

A British company

7597313001

4. Title of the invention

Active Material Low Power Electrical Switching Mechanism

5. Name of your agent (if you have one)

A. A. THORNTON & CO.

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Northumberland House,
303 - 306 High Holborn,
London WC1V 7LE

Patents ADP number (if you know it)

75001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number
(if you know it)

Date of filing
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

- a) any applicant named in part 3 is not an inventor, or
 - b) there is an inventor who is not named as an applicant, or
 - c) any named applicant is a corporate body.
- See note (d))

Patents Form 1/77

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Continuation sheets of this form

Description 6

Claim(s) - 8

Abstract -

Drawing(s) 1 + 1

10. If you are also filing any of the following, state how many against each item.

Priority documents -

Translations of priority documents -

Statement of inventorship and right to grant of a patent (Patents Form 7/77) -

Request for preliminary examination and search (Patents Form 9/77) -

Request for substantive examination (Patents Form 10/77) -

Any other documents (please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature

Date

A. A. THORNTON & CO.

19 April 1999

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr Andrew Crawford - 0171 405 4044

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Notes

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ACTIVE MATERIAL LOW POWER ELECTRICAL
SWITCHING MECHANISM

5 The present invention relates to an electrical switching mechanisms
and more particularly to such mechanisms when used in electrical safety
equipment such as residual current circuit breakers.

 In our earlier international application WO-A-98/40917, we have
disclosed a novel form of electrically activated mechanical release mechanism
which we have termed an actuator which improves the displacement behaviour of
10 active material benders using materials such as piezo-ceramics. A feature of all
active materials is that they are relatively inefficient, having coupling factors
between the driving means and the output of fractions of a percent. Consequently,
actuators which use such materials tend to require high fields be they magnetic or
electric. However, we have found that despite this disadvantage, an actuator
15 utilising an active material bender can result in a product having good mechanical
properties.

 The area of interest in this invention is the field of Residual Current
Devices, known as RCDs. This term covers Residual Current Circuit Breakers
which are not equipped with current limiting capabilities and Residual Current
20 Breakers with Overload which have current limiting portions.

 RCDs function by comparing the current flowing within the live and
neutral conductors, on the principle that it should be equal and opposite. A
variation in the currents indicates a leakage from the circuit which is usually
indicative of a fire risk or a human in danger of electrocution.

25 RCDs are manufactured in many formats, such as adaptors, plugs,
electric socket outlets and consumer unit devices. In performance terms, devices
can be divided into two specific types.

 Line Dependent devices use electronic processing to measure the
differential current and to then trigger an actuator that causes the circuit to be

opened. These devices benefit from being flexible and consistent, because their trip level can be set by the selection of threshold resistors, and the tripping action is not reliant upon the energy within the fault, as the electronics can call upon the mains supply to power the actuator.

5 Line independent devices utilise the energy from the fault itself to initiate the tripping action. This is most commonly achieved through the use of a permanent magnet relay. The principles of permanent relays are well-known, but to summarise a movable metal part is held in a first position by means of a suitable permanent magnet which is surrounded by a coil. When a fault current
10 flows it induces a current within a toroidal transformer connected to the coil surrounding the magnet. The current flow is rectified such that its associated magnetic field opposes that of the permanent magnet until the movable piece is freed. In order to make highly sensitive relays the mating surfaces of the metal parts must be of exceptional flatness, and the system must be totally clean. The
15 flattening and assembly processes are consequently expensive.

 Our International Application WO98/40917 discloses a novel form of actuator suited to active materials, termed a planar bimorph. The same application also discloses a methodology for using such actuators to release mechanisms. Such systems require a large voltage in order to operate, and such
20 voltages cannot presently be generated in line independent systems.

 It is an object of the present invention to provide an electrical switching mechanism utilising an active material bender which is driven by an inductive circuit where output is converted into a high voltage.

 Preferably, the mechanism includes an active material bender as
25 disclosed in our earlier international application no. WO98/40917.

 In order that the present invention be more readily understood, an embodiment thereof will now be described by way of example with reference to the accompanying drawings in which:

 Fig. 1 shows an exploded perspective view of a release mechanism

which can be used as the basis of the present invention; and

Fig. 2 is a circuit diagram of the drive circuit for the mechanisms shown in Fig. 1.

5 The switching mechanism of the present invention comprises a release mechanism and a drive circuit.

The electrically actuable mechanical release mechanisms shown in the accompanying drawings and is constructed from a number of layers of sheet material. The relative thicknesses of the different layers are chosen having regard to the different functions to be performed by the layers and this also applies to the material utilised. For ease of handling in this particular construction, the material is metal strip in which the thickness is readily controlled to acceptable limits by the fabrication process. Thicknesses of 0.15 millimetres to 0.2 millimetres have been found to be suitable but other thicknesses can be used as can other materials for certain of the layers. It is not necessary for the layers to be metal or conductive and in fact, in some instances it may well be an advantage for the layers to be insulative or self lubricating by being manufactured from a suitable plastics material.

The mechanism comprises are substrate 10 to which are attached a stack of other layers the stack comprising a frame 12 a spacer 14 and a planar bimorph layer 16 a slider element 18 is arranged to slide within a profiled channel 30 formed in the frame 12 and the slider is formed with an extension 32 which extends beyond the open end of the profile channel 30 in the frame 12.

The slider 18 is formed with a slot 34 which is arranged to receive a spring 36 with one end of the spring being located on a spring seat 37 with the other end of the spring 36 in engagement with a spring seat 38 provided on one of the other layers, in this case the spacer layer 14. The slider member is capable of being latched against the action of the spring 36 by means of a rotatable pawl 40. The pawl 40 is mounted for rotation by means of a bearing 41 provided in the spacer 14, the spacer also being provided with an actuator 42 through which the

operable, movable tip 44 of the piezo bimorph extends in order to control the rotation of the pole 40 and thus the release or latching of the slider 18.

Before describing the operation of the above described mechanism, it is important to understand that the profiled channel 30 in the frame 12 is specially shaped so that the slider 18 although being largely movable linearly under the action of the spring 36 is also capable of slight lateral or rotational motion. Also, the profiled channel narrows near the open end of the channel so as to restrict the stroke of the slider which is formed with protrusions 46. Also, the pawl 40 has a semi circular portion 48 arranged to be received in a corresponding portion 50 of the profile channel so as to be capable of angular movement in the direction of the arrow A within the profile channel. The pawl is formed with a shaped recess 52 arranged to receive a projection 54 on the end of the slider 18 remote from the spring 36 the shape and size of the meeting projection 54 and recess 52 are carefully designed to provide a specific burst force and the slider is also provided with additional.

Turning now to the operation of the mechanism, let us assume that the various layers are all assembled, stacked one on top of the other with the slider in position in the channel 30 such that a latching surface 56 is in engagement with a latching surface 58 on the frame 12 and the spring 36 is thus in compression between the spring seats 37 and 38. The surfaces 56 and 58 are angled such that the spring force is converted into a rotational force as indicated by the arrow B. This rotation is restricted by virtue of the projection 54 on the slider 18 being restrained by the recess 52 in the pawl 40. Movement of the pawl 40 in the direction of the arrow A is restricted by virtue of the moveable end 44 of the piezo bimorph 16. The operating end of the bimorph is formed with a pen like member which is the depth of the spacer 14 and the slider 18 and this is typically 0.35mm.

When the mechanism is to be actuated, an electrical signal is applied to the piezo bimorph 16 which causes the bimorph to flex in such a way that the pin 44 is pulled upwards, out of the plan of the paper, and out of an engagement

with the pole 40. The shape of the meeting surfaces of the projection 54 and recess 52 in combination with the shape of the meeting surfaces 56 and 58 under the action of the force exerted by the spring 36 causes the slider 18 to start to pivot in the direction of the arrow B which in turn forces the pole 40 to rotate in the direction of the arrow A until such time as the pole 40 releases the projection 54 which permits free movement of the slider 18 firstly in an arcuate direction in the direction of the arrow B and subsequently in the direction of the arrow X so that the tip 32 of the slider 18 can be used to activate a further mechanism or apparatus.

In order to reset and relatch the mechanism, it is assumed that there is no electric signal applied to the bimorph 44 so that the pin 44 is in its down most position. By moving the slider 18 in the direction opposite to the direction 8, the spring 36 is compressed and the slider is moved past the latching projection 58 to permit the projection 54 on the end of the slider to be received in the recess 52 in the pawl. The pawl is resiliently biased by a slight spring force in a direction opposite to the direction of the arrow A so as to permit the projection 54 to be captured by the recess and the pin 44 to hold the capture position.

It will be appreciated that the above construction is capable of being manufactured to any dimensions. In fact, it is very suitable for micro-machining techniques due to the laminar nature of the structure.

Due to the small engagement depth and release force, it is possible to exploit the large motion of the planar bimorph to create a system which operates from a low voltage. A suitable drive circuit for such use will now be described with reference to Fig. 2.

In this embodiment, the sensing means on an RCD is a toroidal transformer 60 which comprises a right turn from the mains line and a number of secondary turns, typically 1000 or more, on the secondary. High permeability materials such as Nickel Iron are used to increase the overall inductance of the system.

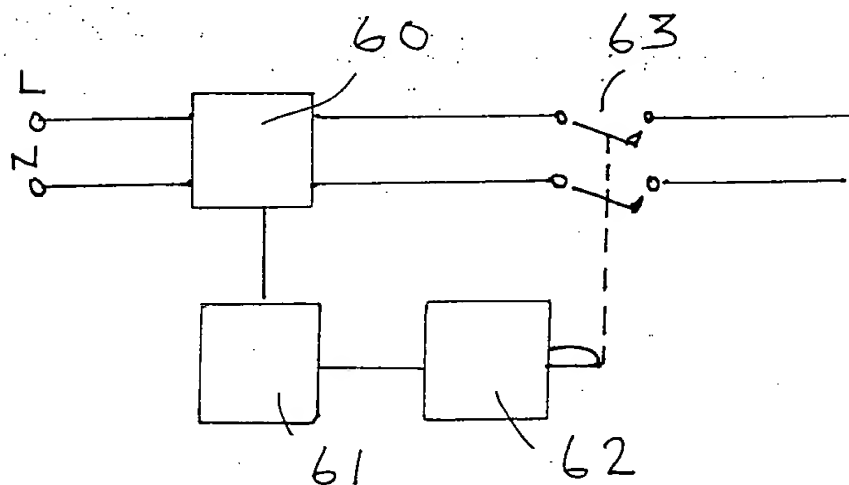
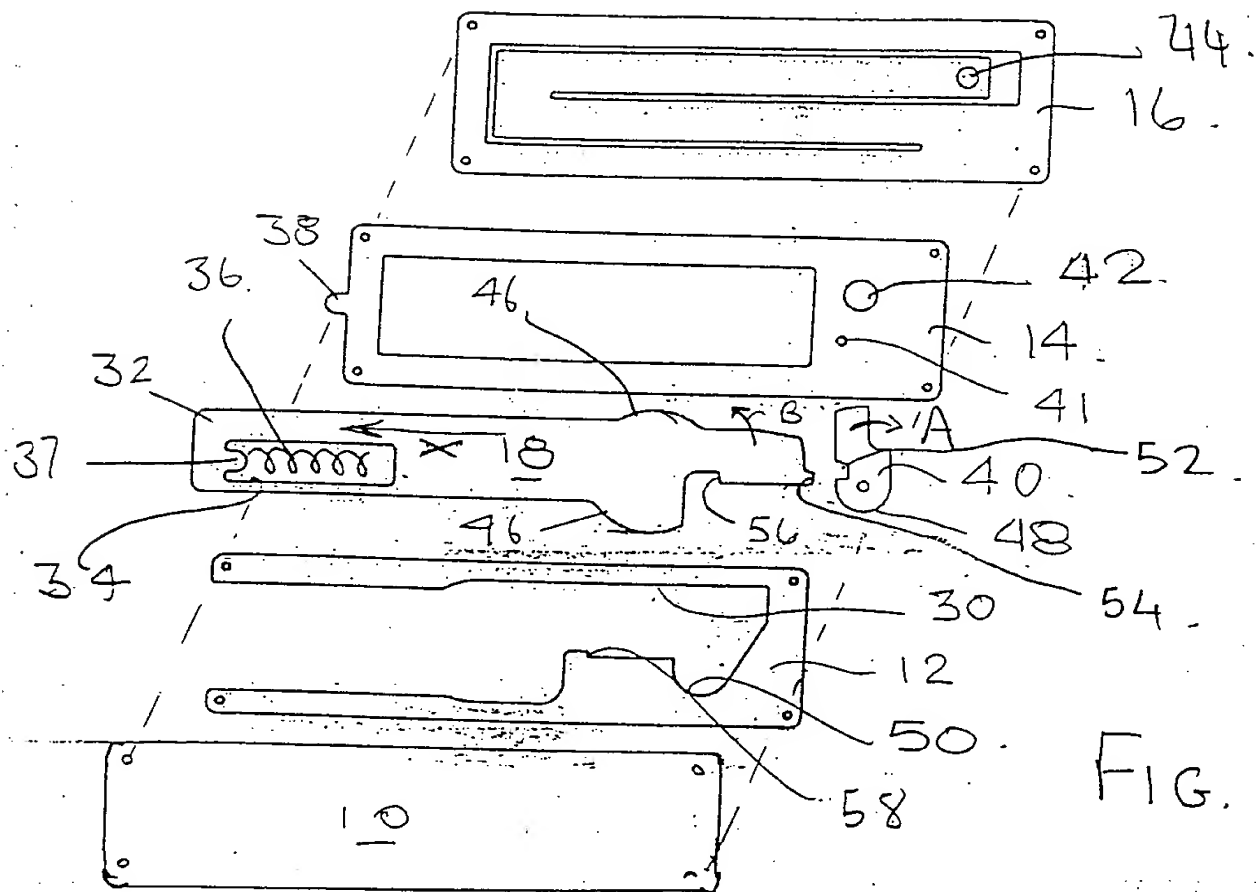
The voltage created in the secondary of such a toroidal transformer

is the back emf to oppose any change in the primary. Under normal circumstances the current flowing in the live and neutral are equal and opposite, so the magnetic fields cancel out. If a proportion of the incoming current begins to flow out of the circuit the fields cease to be equal and opposite, resulting in an induced voltage in the secondary. Initially, the induced waveform is sinusoidal, to match the fault current, but as the fault current increases the toroidal transformer saturates and the output wave form becomes spiked. In traditional electro-mechanical relays this is a disadvantage, because the power delivered decreases.. Piezo electric and electrostrictive materials however are distinctive in being very low power but demanding of an electric field in order to operate. The voltage output of an inductor is calculated by the equation $E = -L \frac{di}{dt}$, where E is the Voltage, L is the system inductance and $\frac{di}{dt}$ is the rate of change of current over time. The saturation of the magnetic core results in a very $\frac{di}{dt}$ and so the voltage goes up. The present invention utilizes this behaviour in order to generate an initially high voltage from the toroidal transformer which is designed to substrate at a point around 50% of the trip value.

The output of the toroidal transformer is then fed to a voltage multiplier circuit 61 where the voltage is doubled or tripled using any suitable circuitry.

The voltage multiplier circuit 61 is then used to drive a piezo ceramic bender such as the one shown in Fig. 1 to then release the contacts 63 of the device.

This arrangement then constitutes a particularly effective low-power line independent device.



PCT/GB00/01508

A A. Thornton & Co

filed 16/5/00

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